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Denise Ravet

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Lean production: the link between supply chain and sustainable development in an international environment

Abstract

Purpose - While there could be separate streams of established research on lean production, global supply chain and sustainable development, the idea is to address the intersection of these strategic initiatives. Firms may find synergies and competitive advantage through these strategies. The aim of the mission is to explore the link between sustainable development, global supply chain and the lean paradigm in the international changing competitive environment. Lean has long been linked to improve operational performance and environmental performance. The concern is to analyze how companies could manage the lean and sustainable principles through the global supply chain in order to take advantage of synergy and to strengthen their operational expertise in an international environment.

Design/methodology/approach - A literature review is conducted to examine research and practice with respect to the implementation of lean production and sustainable, global supply chain strategies. A recent review of the literature in each of the three interfaces of lean, sustainable and global supply chain strategies was conducted using different international databases.

Findings - An examination of the literature reveals drivers and barriers, converging and contradictory elements for the implementation of lean production and sustainable, global supply chain strategies in an international environment. The research tries to highlight the key elements that could inform managerial decision making.

Keywords: Sustainable development/global Supply chain management/Lean production

INTRODUCTION

In the intensive competitive environment of the global economy, the survival of many companies depends on the ability to continuously improve quality while reducing costs. Meanwhile, sustainability is becoming a key issue for manufacturing strategy and in recent past, emergence of customer driven markets has resulted in rapid changes in strategies adopted by the organizations. Manufacturing systems have to respond to continuous changes and sustainability requirements. So, changing production methods from mass-production with high inventory to a leaner operation with low inventory has become an essential practice. Significant interest has been shown in recent years in the idea of “lean manufacturing” (Womack *et al.*1990) and the wider concepts of the “lean enterprise” (Womack and Jones, 1996). Many organizations have adopted the lean thinking paradigm in order to optimize performance and competitive advantage. These paradigms lean and sustainable should not be considered alone or in isolation within the supply chain. The sustainability paradigm has

opened the gate for revisiting various established strategies of supply chain management to reassess their viability with new angle of sustainability in general and greening specially (Stonebraker *et al.* 2009). Tradeoffs between these management paradigms may help organizations and their supply chain to become more competitive and sustainable (Machado, Duarte, 2010). Therefore more attention has been paid to lean and sustainable organizations and supply chains as there is recognition of the need to match the supply chain to the market. So, a key business feature is that supply chains compete, not companies (Christopher, 1992). These supply chains must be able to satisfy the demands of customers.

Consequently, in this context, how can lean production meet global supply chain and sustainable development? The goal of this paper is to present the relationship between lean and sustainable paradigms linked to the supply chain in an international environment in order to identify the possible synergies.

First, we will present the sustainable development paradigm and the link with supply chain, in a second part we will explore the lean paradigm, and then in a third part, in which these two paradigms may be combined to enable highly competitive supply chains capable of winning in an international, volatile and cost-conscious environment.

I- THE SUSTAINABLE DEVELOPMENT PARADIGM AND THE LINK WITH SUPPLY CHAIN

With growing legislation, dwindling resources and increasingly vocal consumers, sustainability will only continue to grow in importance as an opportunity for forward thinking firms and a threat to their competitors that fail to act. Therefore, interest in sustainable supply chains has been growing for over a decade and the topic is becoming mainstream (Corbett and Kleindorfer 2003; Corbet and Klassen 2006). The organizations need to deal with environmental and social issues (e.g., Kleindorfer, Singha and Van Wassenhove 2005; Corbett and Klassen 2006).

I-1-THE CONCEPT OF SUSTAINABILITY AND SUPPLY CHAIN

Sustainable development: Sustainability encompasses complex, diverse issues. “Sustainability can mean different things: some see it in terms of long-term viability, generally with an environmental perspective, some see a dynamic nature in sustainability, some see it simply as lasting change, which is the way in which we will use it here” (Bicheno and Holweg, 2009, p.218). The Brundtland commission (World Commission on Environment and Development 1987, p.8) defined the term of sustainability as: “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. The concept of sustainable development is made up of three areas: economic, social and environmental sustainability. For an organization, it translates as a focus on a respect for: profit-economic; people-social; and environment-environmental. The study is especially on corporate sustainability which has been defined as a business approach that creates long-term shareholder value by embracing the opportunities and managing the risks associated with economic, environmental and social developments. Corporate sustainability

has been focused with attention drawn toward the triple bottom line of “people, profit and planet” (Elkington, 1994, 1998) or “Equity, Environment and Economics” (Anderson 2006; Kleindorfer *et al.* 2005). Sustainability emerges as a way of considering the environmental and social values of business decisions alongside their economic value.

Supply chain. In the early 1980s firms realized that their competitiveness was not just determined by what they do, but also by what their upstream suppliers and downstream suppliers were doing. Supply chain capabilities are a significant determinant of competitiveness and it can be argued that value chains compete, not individual companies (Christopher, 2000). The key point in supply chain management is to consider the entire system of suppliers, manufacturing plants, and distribution tiers. The supply chain management can be defined as a set of interdependent organizations that act together to control, manage and improve the flow of materials, products, services and information, from the origin point to the delivery point (the end customer) in order to satisfy the customer needs, at the lowest possible cost to all members (Lambert, Stock, Ellram, 1998). According to Christopher (2000), the goal is to manage upstream and downstream relationships with suppliers and customers in order to create enhanced value in the final market place at less cost to the supply chain as a whole. More recently, another definition specifies that supply chain is a group of partners who collectively convert a basic commodity (upstream) into a finished product (downstream) that is valued by end-customers, and who manage returns at each stage (Harrison, Van Hoek, 2005). It highlights the reverse logistic and its importance in the supply chain. The success or failure of the supply chains is ultimately determined in the marketplace by *the end consumer*. Customer satisfaction and marketplace understanding are crucial elements for consideration when attempting to establish a new supply chain strategy. When the requirements and constraints of the marketplace are understood can an enterprise attempt to develop a strategy that will meet the needs of both the supply chain and the end customer?

I-2 MANAGING GLOBAL SUPPLY CHAINS

In order to meet the current challenges of the global economic crisis, supply chains have to change especially with systematic controlling of net working capital. Globalization has a central role to play in supply chain management: supply chains are increasingly global and complex, as companies aspire to support a variety of strategies, such as entering new markets, increasing service to customers and reducing costs. According to surveys¹, the most important drivers of globalization are factors that are directly connected to purchasing and procurement, followed by drivers on the market side. “In times of economic crisis, active management of net working capital, in other words of inventories, receivables and payables is one of the core tasks of supply chain management. Companies should now make use of every opportunity to release capital in the short term in order to improve cash position. Controlling net working

¹ ATKEARNEY 2009

capital is often a neglected instrument for doing this. What it is important for the people in charge of supply chain management is that they reduce their inventories, perhaps by systematically restructuring the supply chain to become a pull supply chain". The effects of globalization are apparent in the interdependencies of suppliers and customers. The global trends influence the supply chain management goals: reducing costs, improving customer service, getting new products and services to market faster and sustainable actions. On the one hand, supply chain cost and tied-up working capital, including inventories, must be kept as low as possible. On the other hand, though, customer requirements in terms of delivery lead times, product availability and delivery reliability are increasing. Reducing costs is even more important for companies in developing markets; perhaps companies in countries such as China are trying to anticipate the effect of rising costs (including labor costs and appreciating currencies) on the competitive advantage they currently enjoy as low-cost manufacturers. In this context, supply chain strategies are increasing the efficiency of supply chain processes, actively managing risks along the supply chain, and sourcing more inputs from low-cost countries. Many companies manage both sourcing and logistics outside the home country for cost reduction. When possible, companies seek to maximize economies of scale in the supply chain, and many companies treat it as a shared utility of the broader organization – not only to take advantage of synergies, but also to strengthen their operational expertise. The top-rated challenge is the ability to share knowledge effectively across different manufacturing and sourcing locations. Against a backdrop of sharply rising supply chain risk, including the prospect of higher energy prices, companies are likely to pay attention at their manufacturing and supply footprints.

I-3 SUSTAINABLE DEVELOPMENT AND SUPPLY CHAIN

In the wake of concerns regarding climate change, pollution and non-renewable resource constraints, firms are heeding stakeholder demands regarding corporate citizenship behavior and performance (Sarkis, 2001). The various stakeholders – customers, shareholders, boards, employees, governments, and NGOs – and most corporations respond in a reactive, piecemeal way that could influence the supply chain. So, efforts to make supply chains more environmentally friendly has gained top priority due to increasing threats arising out phenomena like global warming and climate change (Shukla *et al.* 2009b). Several other factors lead firms to pursue sustainable supply chain practices: pressure from stakeholders (Zhu *et al.*, 2008), environmental standards (Rondinelli and Berry, 2000), effects of environmental performance, on firms' reputations (Christmann, 2000), cost reduction (de Brito *et al.*, 2008) and competitors (Walker *et al.*, 2008). Moreover, environmental regulations, have forced manufacturers to re-examine the entire lifecycle and environmental impacts on their products. Such compliance efforts have already resulted in cleaner, safer operations, reduced use and acceptable substitutions for hazardous substances, increased product recyclability and recovery, and improved transparency of information available to suppliers, trading, partners, employees, and customers that impact all the supply chain. Consequently, many manufacturing companies are adopting sustainability initiatives in response to internal drivers such as cost reduction, commodity risk management, and

upholding corporate culture and external drivers (consumers want the right product at the right cost to the right place at the right time and to be green). Several examples can underline these different actions: Unilever² has decided to carry 30% of its freight by other means than road transportation thanks to collaboration with its logistic subsidiary and information sharing through the Carbon Disclosure Project Supply Chain Leadership Collaboration³. By coordinating across every stage of fabric and shirt production, the Chinese manufacturer Esquel cut energy consumption by 26.4 % and water consumption by 33.7 % in the past five years (Lee, 2010). Lafuma has been implementing sustainable development actions since the 1990's. An in-house organization was set up with sustainable good practices at every level, including product design, manufacturing/sourcing, transport/logistics, human resources, sales and communication. The commitment to sustainable development for Lafuma⁴ is ambitious specifically by the completion of an eco-designed line of products for each product range. Hewlett-Packard is one of the world's leading companies that belong to the United Nations global compact⁵ in order to align its operations to accepted principles. Thus, a sustainable supply chain focus requires working with suppliers and customers, analysis of internal operations and processes, environmental considerations in the product development process, and extended stewardship across products' life cycles (Corbett and Klassen, 2006; Mollenkopf, 2006). But, sustainability issues are adding complexity and risks to the already challenge of managing supply chains such as inventory, cycle time, quality, the costs of materials, production and logistics (Lee, 2010). Three distinct phases of supply chain are identified in the literature (Shukla, 2004):

- *Inbound* supply chain ensure value addition to raw materials in terms of selection, segregation, packing, transportation, cold storing, warehousing etc... There are host of intermediate echelons like consolidators, traders, commission agents, wholesalers, retailers, third party logistics, which results in very high complexity. It implies green-design, green sourcing... Greening the supply chain generates environmental benefits as well as financial results by reducing risk by managing a product's environmental compliance in its design rather than making any necessary costly corrections later in its lifecycle.
- *Manufacturing* supply chain or internal supply chain: value addition is done during manufacturing or production of goods. Functions like material flow, material handling and inventory management are predominant and implies green manufacturing.
- *Outbound* supply chain : the distribution channel operations like warehouse location, mode of transportation and inventory management at retail and wholesaler level... it implies green logistic and green reverse logistic.

Although sustainability measures often seem worthwhile individually, they may in the grand scheme generate unintended consequences, such as higher financial, social, or environment costs (Lee, 2010). Consequently, these sustainability measures must be coordinated across every stage of the supply chain with adjacent operations. Equally this is the reason why a

² Logistique magazine Juin 2010

³ CDP is an independent not-for-profit organization holding the largest database of primary corporate climate change information in the world.

⁴ Lafuma annual report 2010

⁵ United Nations Global Compact is a strategic policy initiative for businesses that are committed to aligning their operations and strategies with ten universally accepted principles in the areas of human rights, labour, environment and anti-corruption.

sustainable supply chain is one that performs well on both traditional measures of profit and loss as well as the triple bottom line (Elkington 1999, Kleindorfer *et al.* 2005). The triple bottom line is a tool to measure an organization's progress toward the end goal of being truly sustainable.

Moreover, the development of sustainable has tended to focus on studies of a single function or activity as opposed to looking at the entire chain (Rao and Holt, 2005). But, companies – throughout the supply chain, not just at the end – should take a holistic approach to sustainability and pursue broader structural changes than they typically do. It is mainly important in an international supply chain.

Therefore, the sustainability paradigm may have influence on the supply chain and many supply chain decisions may have impacts on the environment, the social aspects, the communities and the wider supply chain.

II -THE LEAN PRODUCTION PARADIGM

II-1 LEAN ORIGINS

The origins of lean manufacturing initiatives can be traced to the Toyota Production System (TPS) and were initiated by Ohno (1978) and Shingo (1989) at Toyota with its focus on the systematic efficient use of resource through level scheduling. They used the Japanese word “muda”, which were defined as any human activity that absorbs resources but creates no value (Dettmer, 2008). Taiichi Ohno has identified the first seven type of “muda” (means waste) and the main goal is on the systematic identification, reduction and elimination of all waste from the manufacturing processes in order to create value for the customer. In the lean context, waste was viewed as any activity that does not lead directly to creating the product or service a customer wants. Then, the *lean production* was coined by Womack *et al.* (1990) in their book entitled “The machine that have changed the world” in order to show a better way to organize and manage customer relations, the supply chain, product development, and production operations, an approach pioneered by the Toyota Company after World War II. This is a vision of a world transformed from mass production to Lean Production which has dominated much of the theory and practice of production systems design. In this context, the idea of “lean thinking” has been expounded by Womack and Jones (1996) and have emphasised Lean Enterprise rather than Lean Production (Womack *et al.*, 2003). Today it is arguably the paradigm for operations that can be found in a wide range of manufacturing and service strategies.

II-2 LEAN DEFINITION

Formulating a definition that captures all the dimensions of lean is a formidable challenge (Pettersen, 2009). The terms “lean production” or “minimum workshop” as Ohno (1978) states, provide a way to do more and more with less and less – less stock, less human effort,

less equipment, less movement of material, less time and less space while coming closer and closer to providing customers with exactly what they want. It is the single most powerful tool available for creating value while eliminating waste in any organization (Womack and Jones, 1996). Leanness means developing a value stream to eliminate all waste including time, and to enable a level schedule (Naylor *et al.*, 1999). The systematic attack on waste is also a systematic assault on the elements underlying poor quality and fundamental management problems (Childerhouse and Towill, 2002). According to Seth and Gupta (2005), the goal of lean manufacturing is to reduce waste in human effort, inventory, time to market and manufacturing space to become highly responsive to customer demand while producing quality products in the most efficient and economical manner. Lean manufacturing results could include reduced inventory level (raw material, work in progress, finished product) ; decreased material usage (product inputs, including energy, water, metals, etc...) ; optimized equipment (capital equipment for direct production and support purposes) ; reduced need for factory facilities; increased production velocity; enhanced production flexibility; and reduced complexity (Shashin, Janatyan, 2010). MIT's Lean Advancement Initiative defines lean as follows: production design that is aimed at the elimination of waste in every area, including customer relations, product design, supplier networks and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products and less space to become highly responsive to customer demand, while producing top-quality products in the most efficient and economical manner possible. The term is often used in connection with lean manufacturing to imply a "zero inventory" just-in-time approach.

II-3 LEAN THINKING AND PRODUCTION PRINCIPLES

The lean thinking can be summarized in five principles: "precisely specify *value* by specific product, identify the *value stream* for each product, make *value flow* without interruptions, let the customer *pull* value from the producer, and pursue *perfection*". By clearly understanding these principles, and then tying them all together, managers can make full use of lean techniques and maintain a steady course"(Womack and Jones, 2003).

-The starting point is to specify value from the point of view of the customer. This is an established marketing idea that customers buy results, no products. Organizations begin to accurately specify value. The value can only be defined by the ultimate customer and it's only meaningful when expressed in terms of specific product which meets the customer's needs at a specific price at a specific time. Lean thinking must start with a clear definition of value. It's essential to have a clear view of what's really needed. To specify value accurately is the critical first step. It is important to rethink value from the perspective of the customer.

-Identify the value stream. This is the set of all the specific actions or process required to bring a specific product from raw material to final customer, or from product concept to market launch through the three critical management tasks of any business: the problem solving task, the information management task, the physical transformation task. The map and the measure of the value stream should be done end-to-end and not departmentally. So, the

focus should be done on the object (or product or customer), and not on the department, machine or process step.

-To make the value-creating steps for specific products flow continuously thanks to production team. The goal is to avoid batch and queue, or at least continuously reduce them and the obstacles in their way.

-Let customers pull value from the enterprise: it is the ability to design, schedule, and make exactly what the customer wants just when the customer wants. You can let the customer pull the product from you as needed rather than pushing products.

-Perfection: it means delivering exactly what the customer wants, exactly when (with no delay), at a fair price and with minimum of waste.

-Lean is a business model emphasizing the elimination of waste while delivering quality products at the least cost.

While most of the research stresses that competitiveness of lean production comes from physical savings (less material, fewer parts, shorter production operation, less unproductive needed for set-ups, etc...) on the technical side, a focus is also done on the “psychological efficiency” (commit, cognition, empowerment, communication, and autonomous, etc..) the peripheral of the organizational mechanism. Lean production is not just a technological system but also a concept implemented throughout the whole company, which especially requires consensus on corporate culture (Wong, 2010). Lean production system has been one of the competitive advantages for Japanese enterprises, and the cultural element behind it (Recht and Wilderom, 1998).

II-4 LEAN PRODUCTION, SUPPLY CHAIN STRATEGIES

The lean model requires less stock, less space, less movement of materials, less time to set up the machinery, a smaller workforce, fewer computer systems and more frugal technology (Shahin, Janatyan, 2010). Consequently, lean supply chains strategies focus on waste reduction, helping firms eliminate non-value adding activities related to excess time, labor, equipment, space and inventories across the supply chain (Corbett and Klassen, 2006). Such strategies enable firms to improve quality, reduce costs, and improve service to customers (Larson and Greenwood, 2004). According the taxonomy for pipeline selection (Christopher, Peck, Towill, 2006), a matrix suggests that there might be four possible generic supply chain strategies according to three-dimensional classification (products, demand, replenishment lead-times): lean (plan and execute), leagile (postponement), lean (continuous replenishment), agile (quick response). It has been suggested that lean concepts work well where demand is relatively stable and hence predictable and where variety is low (Christopher, 2000). Now the lean production paradigm positively impact many markets sectors where cost is the primary order criteria (Hill, 1993). So, where demand is volatile and the customer requirement for variety is high, a different approach is recommended. A “hybrid” solution can utilize lean

principles when designing supply chains for predictable standard products and agile principles for unpredictable or “special” products. It may be that total demand for a product can be separated as “base” and “surge” demand. Base demand is more predictable and less risky so lean principles can be applied, using agile approaches to cope with surge demand (Christopher, Peck, Towill, 2006). It is also likely that products may require different kinds of pipeline according to their position within the product life cycle. Fisher (1997) claims that the reason why so many supply chain implementations fail is that they are wrongly configured according to demand. He indicates that there are two categories of demand : Functional – typically predictable, low margin, low variety, with longer life cycles and lead times, and no need to mark down at end of season, and Innovative – typically less predictable, high margin, high variety, shorter life cycles and lead times with end of season discounting common. Functional requires an efficient process or supply chain, Innovative requires a responsive process. Mismatches between demand and process give problems. For lean strategies the implications are that a product requiring a responsive supply chain would be inappropriate in a low cost distant location. This may well mean having more than one type of facility and demand chain to cope with different demand segments. Finally, the supply chain strategy depends upon the supply and demand characteristics. If lead times are long but demand is predictable “lean strategies” are possible, e.g make or source ahead of demand in the most efficient way.

II-5 LEAN PRODUCTION, SUPPLY CHAIN STRATEGIES AND SUSTAINABLE DEVELOPMENT

The causal relationship between lean processes and environmental sustainability has been much debated in literature (King and Lenox, 2001). Recent academic research (Hines, 2010) and surveys find the most compelling reason for organizations adopting lean is the economic and environmental benefits of going green. The consumer pressures to provide the right product at the right cost to the right place at the right time and to be green. Sustainability has become one of the big themes in lean particularly from an environmental perspective. The ideas of wasting fewer materials and energy and avoiding polluting emissions fit extremely well with wider lean ideas. These paradigms lean and sustainable may be combined to enable highly competitive supply chains capable of winning in a volatile and cost-conscious environment. The goal is to examine the relationship between these supply chain strategies, including their convergence and divergence.

Lean and green strategies are often seen as compatible initiatives because of their joint focus on waste reduction (Mollenkopf *et al.*, 2010). Womack (2000) underlines that lean thinking must be “green” because it reduces the amount of energy and wasted by-products required to produce a given product...Indeed, examples are often cited of reducing human effort, space, and scrap by 50 % or more, per product produced, through applying lean principles in an organization...this means that...lean’s role is to be green’s critical enabler as the massive waste in our current practices is reduced. In these challenging economic times for

manufacturers, lean could be a priority. Lean manufacturing drives more effective and efficient resource utilization, reduces waste and energy consumption, optimizes direct and indirect resources and helps ensure a better product at less cost. The lean philosophy, eliminating waste, essentially comes down to taking many small actions to create big results. But, it seems important to differentiate “waste of time” and “waste of raw materials” as only in certain conditions it is possible to combine the both. So, more and more manufacturers are extending lean practices beyond the shop floor to enable green initiatives and meet sustainability mandates. Lean produces an operational and cultural environment conducive to waste minimization and pollution prevention. Indeed, the powerful economic and competitiveness drivers behind lean drive a willingness to undertake substantial operational and cultural changes, many of which have important environmental performances implications. Lean typically results in less material use, less scrap, reduced water and energy use, and decreased number and amount of chemicals used. So, becoming greener can reduce operating costs significantly and add customer value, two primary tenets of any lean initiative.

Moreover, mass production led to economies of scale that reduced costs – as long as the company was making a single model with no options. Today, consumers demand a customized product. Lean focuses on eliminating unnecessary delays and movement. It creates economies of speed that reduce costs and boost profits while minimizing environmental impacts. Whereas mass production focuses on big batches, lean focuses on small batches and quick changeover. With mass production, it’s easy to have overproduction, which creates inventory that has to be warehoused and managed. Lean only creates a small batch when a customer requests it, thereby avoiding all unnecessary production or inventory. It no longer makes sense to create a thousand units of a product quickly if consumers want a product customized to their needs. So, the environmental impact that a shift from mass production to lean production could produce is important. If a company only prepares enough products or services to meet customer demand, it doesn’t have to inventory, store, or manage a lot of raw materials or finished goods. This prevents the unnecessary movement of inventory, and reduces storage costs and overtime. Lean production can lead to both a greener planet and increased profits. Thus, eliminating delays and movement while reducing batch sizes and inventory not only speeds things up, it also reduces the chance for error. Faster production – combined with less rework cuts costs – boosts profits and reduces environmental impacts that range from the overuse of raw materials to high energy consumption. Lean is not just about the bottom line or worker satisfaction, but it is also about green initiatives.

Furthermore, leading organizations go beyond the basics of cutting waste and operating efficiently. They embed environmental considerations into *all aspects* of their operations. Most businesses overlook the single biggest opportunity they have to go green – simplifying, streamlining and optimizing their internal operations. Eliminating activities that do not add value to the customer is the real key to shop-floor effectiveness and enhancing green initiatives within the organization. Software capabilities, value stream mapping, inventory optimization can contribute to reduce inventories and lead times and to improve the financial

results by productive and valuable activities. So, green opportunities for identifying and reducing waste in the lean supply chain can be found in various places: material costs, consumption of energy and natural resources, equipment efficiency, and education of key stakeholders. It's also reasonable to assume that eliminating waste, scrap and rework would reduce not only costs but various environmental problems. In global companies, the adoption of lean and green strategies in manufacturing organizations has resulted in processes becoming more flexible, responsive, and competitive. With this improved responsiveness, organizations can quickly adapt to the increasing complex demands of global manufacturing demands that require more connectivity and more effective communication, among suppliers, and information system (ERP). What Wal-Mart and other retailers have recognized and driven into the manufacturing sector is that aligning green with lean across the entire supply chain drives both top line growth and margin improvements while gaining respect from customers and consumers. How manufacturers can expand lean philosophies and best practices into their sustainability initiatives. Wal-Mart CEO Lee Scott has said "Being a good steward of the environment and in our communities, and being an efficient and profitable business, is not mutually exclusive. In fact they are one in the same". But if Wal-Mart has made some considerable changes with a strong commitment to being green, the question of Wal-Mart's Social responsibility has been criticized for underpaying its workers, offering limited benefits, exploiting employees around the world...In order to have a good responsible corporate social reputation, the company has realized investments in this field (for example, recognition of the Wal-Mart de Mexico Foundation for its social responsibility actions)⁶. So, manufacturing companies can proactively enable sustainability across all key business processes in their organization by implementing the principles of lean. The underlying principles build efficiency within the enterprise and across the entire supply chain, helping companies maintain success through continued process improvement. A lean solution for manufacturing ensures that plants, lines and machines run at peak efficiency – a key component of enabling sustainability. It also ensures necessary spare parts for maintenance are aligned with production requirements ensuring minimum down time and optimizing runs. In the extended supply chain, lean solutions help align demand to capacity to optimize production lines, and maximize energy and raw product utilization. For example, consumer companies can apply lean principles to tightly align packaging material to specific production events, resulting in more efficient use of materials, reduced waste and improved line and machine utilization. While the issue of sustainability continues to mature and evolve, companies looking to take a leadership position and enhance their business advantages can get started by implementing and expanding lean manufacturing solutions across the entire supply chain to address the many aspects of meeting their sustainability and revenue targets. For example, although the main goal is to convert muda into value, the question is also where the value is created. Equally, lean in the product development stage meets green goals by using less materials and chemicals, yielding less waste, and reducing the consumption of energy and natural resources.

⁶ Wal Mart Sustainability Report 2010

The best practice is to take into account the environmental compliance throughout the entire product lifecycle, from concept to launch and into retirement, by integrating compliance into their product development lifecycle processes. Successful product lifecycle management (PLM) solutions enable organizations to manage and optimize the compliance of their products and programs with the standards and regulations of the government and industry. These solutions should merge compliance activities with product development and introduction processes, allowing companies to more reliably comply with environmental standards. Manufacturers must be concerned with controlling pollution and environmental waste at its source in order to address the rising cost of energy and natural resources and the negative impact on climate change and global warming.

Besides, manufactures today are under pressure to adopt these strategies “Lean and Green” and to create an environmental stance that is a driver for reduced costs and risks, increased revenues, and improved brand image. Environmental regulations like the Restriction of Hazardous Substances (RoHS) directive, the Waste Electrical and Electronic Equipment (WEEE) directive, the Restriction, Evaluation, and Authorisation of Chemicals (REACH) regulation have forced manufacturers to re-examine the entire lifecycle and environmental impacts on their products. King and Lenox (2001) find that establishments that adopt the quality management standard ISO 9000 are more likely to adopt the environmental management standard ISO 14000. They also find strong evidence that lean production as measured by ISO 9000 adoption and low chemicals inventories is complementary to waste reduction and pollution reduction. Therefore, such compliance efforts have already resulted in cleaner, safer operations, reduced use and acceptable substitutions for hazardous substances, increased product recyclability and recovery, and improved transparency of information available to suppliers, trading, partners, employees, and customers. Nevertheless, tools and techniques (for example Plan Do Check Act, one of the principle mechanisms for the scientific approach in the Toyota Production System) should be treated as hypotheses to be tested in the particular situation at hand. Otherwise organizations often fail to allow for local factors influencing the successful application and sustainability of tools and techniques (Bicheno and Holweg, 2011).

Finally, lean production and sustainable supply chain create their “eco-advantage” in three main ways:

- Eco-efficiency (cutting out waste, using resources productively, and minimizing the carbon footprint). Lean methods can develop sustainable green practices, particularly in the area of waste reduction.
- Eco-innovation (improving product and service designs so they’re based on green processes by products and designing for recycling)
- Eco-transparency: gaining and sharing full visibility into the value chain so that your business can promote its green brand and enhance and protect its overall brand.

In fact, manufacturers can still achieve cost savings in addition to environmental benefits by integrating their Lean and Green initiatives. Therefore, lean have long been linked to improved operational performance. And there is evidence that these process improvement

philosophies and their associated tools improve environmental performance as well (e.g, Clark 1999; Curkovic, Melnyk, Handfield and Calantone 2000; king and Lenox 2001).

However it is also possible that these programs, while useful, are not sufficient to become sustainable and long term could even be hindrances (Benner and Tushman 2002). When lean initiatives enable only demanded volumes to flow through the supply chain (and not the safety stock and extra inventory associated with non-lean supply chains), a reduced amount of inventory needs to be sourced, produced, transported, packaged and handled, which also minimizes the negative environmental impact of the supply chain.

Furthermore, lean strategies that employ just-in-time (JIT) delivery of small lot sizes can require increased transportation, packaging, and handling that may contradict a green approach (Mollenkopf *et al.*, 2010). Rothenberg *et al.* (2001) indicates that not all lean processes and waste reduction are positively related to environmental performance or pollution reduction. For example, failing to adopt a holistic view of the supply chain might result in the transfer of wastes to other members of the supply chain, thereby not eliminating waste by simply shifting it to others. If management in the manufacturing company focuses internally to become leaner and pushes inventory away to customers and suppliers, the supply chain could be worse-off than if the manufacturing company holds the necessary amount of inventory to make the supply chain as a whole more efficient, particularly if the inventory costs are higher for other parties in the supply chain. The manufacturing company might be leaner, but the costs and burdens associated with the supplier's waste ultimately will be passed along to the customer. The implementation of lean thinking requires extending its application across the operations of the key members of the supply chain (Goldsby, Garcia-Dastugue, 2009).

Moreover, a supply chain may be currently utilizing its resources efficiently, and producing the desired output, and have sustainable effects but will the supply chain be able to adjust to changes like product demand, supplier shortages, manufacturing unreliability...with the same sustainable effects? For example, a reduction in system resources may negatively affect the supply chain's flexibility. Lewis (2000) suggested that being "lean" can curtail the firm's ability to achieve long-term flexibility and sustainable competitive advantage". Moreover, although lean currently produces environmental benefits and establishes a systematic continual-improvement-based waste elimination culture, lean methods do not explicitly incorporate environmental performance considerations, foregoing some environmental improvement opportunities. From these perspectives, lean production and sustainable supply chain could have contradictory sustainable effects. By recognizing this conflict, firms may be able to identify trade-offs or develop solutions that mitigate undesirable consequences.

Thus, there is a need to develop a system approach to understand how firms can best manage these paradigms to optimize the sustainable supply chain as a whole. Different solutions could be possible and be condensed in three themes:

- International best practices.

The best practices in lean and supply chain management that have received significant attention in regard to sustainability are collaboration and certification. Collaborative behaviors with suppliers and customers are a component of creating an environmentally sustainable supply chains (Carter and Carter 1998; Zhu and Sarkis 2004). Goodman (2000) posits that there have to be incentives to reduce suppliers' risks from engaging in the new collaborative processes required by sustainability. And Rao and Halt (2005) suggest that firms need to educate their suppliers and have their suppliers educate each other. Furthermore, certification is one of the few areas where social issues such as child labor and unsafe working conditions are addressed in the sustainable supply chain management literature (e.g, Teuscher, Gruninger and Ferdinand 2005). So, international cross-functional collaboration and international certification will increasingly differentiate companies that meet the full range of their strategic goals from those that don't. Companies that can ensure closer partnerships between international operations and groups will be able to respond more quickly to changing trends at lower costs and with a better competitive advantage. Best practices could be identified for implementing lean sustainable supply chain and could be driven by key performance indicators, company's carbon footprint that could measure or monitor sustainable supply chain.

- Integration

To create the link between lean and sustainable supply chains need to integrate lean principles, sustainability goals, supply chain, practices and cognition into day-to-day management (Pagell, Wu, 2009). At the firm level there is evidence that linking sustainability goals and measures to corporate strategy helps to integrate sustainability into what the organization does (Azzone and Noci 1998). At the individual level, employees need to be trained in sustainability (Starik and Rands 1995) and then given incentives to follow through (Daily and Huand 2001). Such linkages provide employees the incentives to pursue sustainability goals such as quality improvement. Without these incentives employees are likely to continue pursuing only traditional goals (Handfield, Melnyk, Calantone and Curkovic 2001). Lean provides an excellent platform for broadening companies' definition of waste to address environmental risk and product life cycle considerations. Possible coordination or collaboration could exist between the environmental and lean networks. Many consumer manufacturing companies are adopting sustainability initiative in response to internal drivers such as cost reduction, commodity risk management, and upholding corporate culture. Clos-knit collaboration between retailers, distributors and manufacturers appears to be the driver of success for sustainability initiatives. The green supply chain literature has examined the importance of working across the supply chain with both customers and suppliers on environmental initiatives, which has been shown to lead to improved firm performance (Vachon and Klassen, 2006b). More research on the subcomponents of the supply chain should be undertaken to understand how to obtain synergies from the drivers, overcome the barriers, and make trade-offs where necessary (Mollenkopf *et al.*, 2010). Points

of convergence have been identified and some principles could be either a driver or a barrier, depending how firms optimizes the trade-off between the two paradigms. This could be done by mapping internal supply chain operations. Identify where environmental and social-responsability problems or opportunities lie. Evaluate alternative ways to make improvements that may require trade-offs between the different paradigms. Thus, it seems to be important to make an assessment of the points of convergence and divergence across these paradigms in terms of sustainable supply chain especially by the value stream map approach.

-Reinvent the supply chain:

A different theme is on reconceptualizing the supply chain and changing managerial cognitions. An important theoretical discussion suggests that an organization should consider its relationships with the broader social and natural environments. There as a member of the community where its business is conducted, an organization should consider the well-being of broader constituents in the social-ecological-industrial system (e.g, Shrivastava 1994).

Consequently, companies should pursue broader structural change than they typically do. These may include sweeping innovations in production processes, the development of fundamentally different relationships with business partners that can evolve into new service models (Lee, 2010). The transformation – something radical with supply chain could share networks with adjacent operations, the extended supply chain and different competitors.

The transformation could be done thanks to third parties logistics in order to analyze and test the opportunities.

CONCLUSION

An attempt has been made to present lean and sustainable paradigm in the light of international supply chains. Lean production has an impact on the global sustainable supply chain and conversely but it is difficult to estimate the real effect given the supply chain complexity according to different drivers and barriers. It should be recommended to assess this link in a holistic approach to sustainability. Indeed, the only way companies can recognize and navigate trade-offs or conflicts in their supply chains is to treat sustainability as integral to operations (Lee, 2010) on international markets with suppliers and customers.

Trade-offs between emissions and profitability may lead companies to explore new kinds of supply relationships, including the transfer of best practices to supply chain partners. Company's carbon footprint could be major strategic considerations for supply chains. But this model encompasses only some of the many dimensions of the sustainability. Consequently, it could be interesting to refer to ecological footprint models since their scope is more holistic than the carbon footprint in order to ensure that all supply chain members meet agreed-upon sustainable standards and targets. To create a link between lean production and global sustainable supply chains then seems to require proactive top management culture that lean, sustainability and supply chain is a cross-organizational commitment for an overall operational performance.

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